Phenological Responses of Upland Rice Grown Along an Altitude Gradient

Suchit Shrestha[1], Folkard Asch[1], Holger Brück[1], Alain Ramanantsoanirina[2], Julie Dusserre[3]

[1]University of Hohenheim, Germany; [2]FOFIFA, Madagascar and [3]CIRAD, France

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INTRODUCTION

- Crop adaptation strategies are required for varietal development and crop management to avoid negative impacts of climate change.
- Characterization of potential upland rice ideotype traits is necessary to fit genotype into the crop production system.
- Phenology of upland rice responds to temperature/altitude gradient.
- Spikelet sterility needs to be considered along with crop phenology to fit genotype to the crop production system.

OBJECTIVES

- To identify phenological responses to altitude gradients.
- To asses the impact of sowing date on spikelt sterility in contrasting environments.

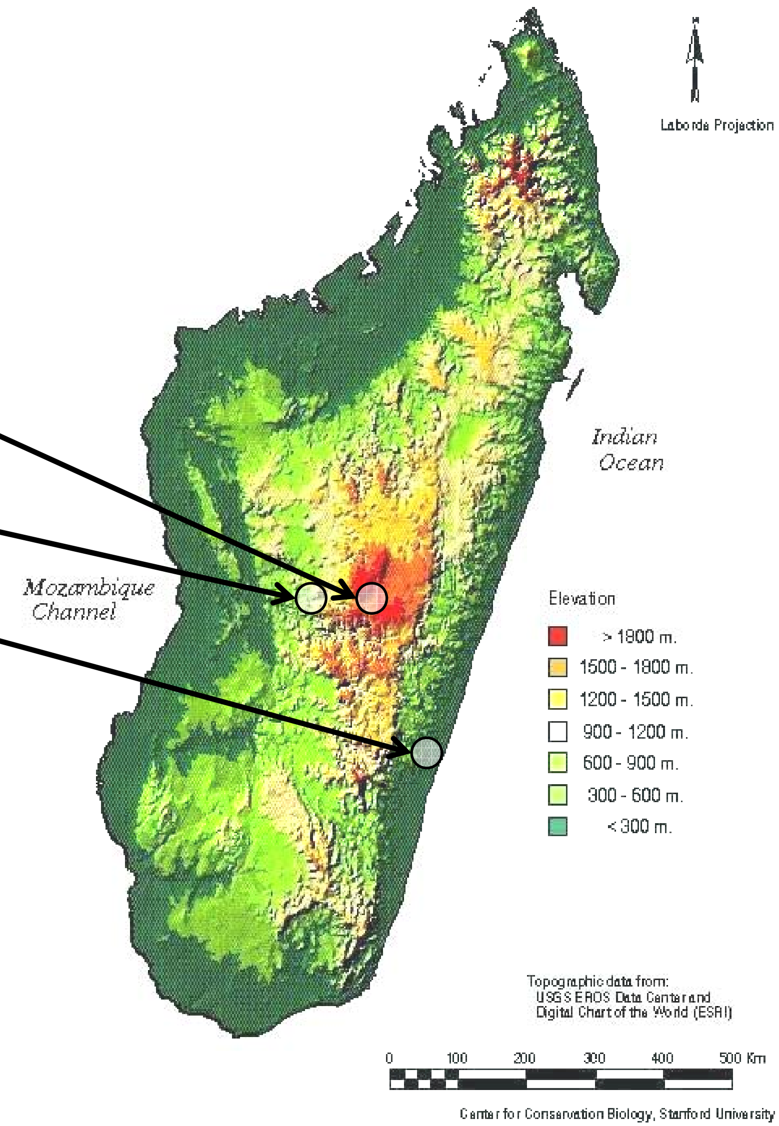
MATERIALS and METHODS

Locations

High altitude (Andranomanelatra)

Mid altitude (Ivory)

Low altitude (Ankepaka)



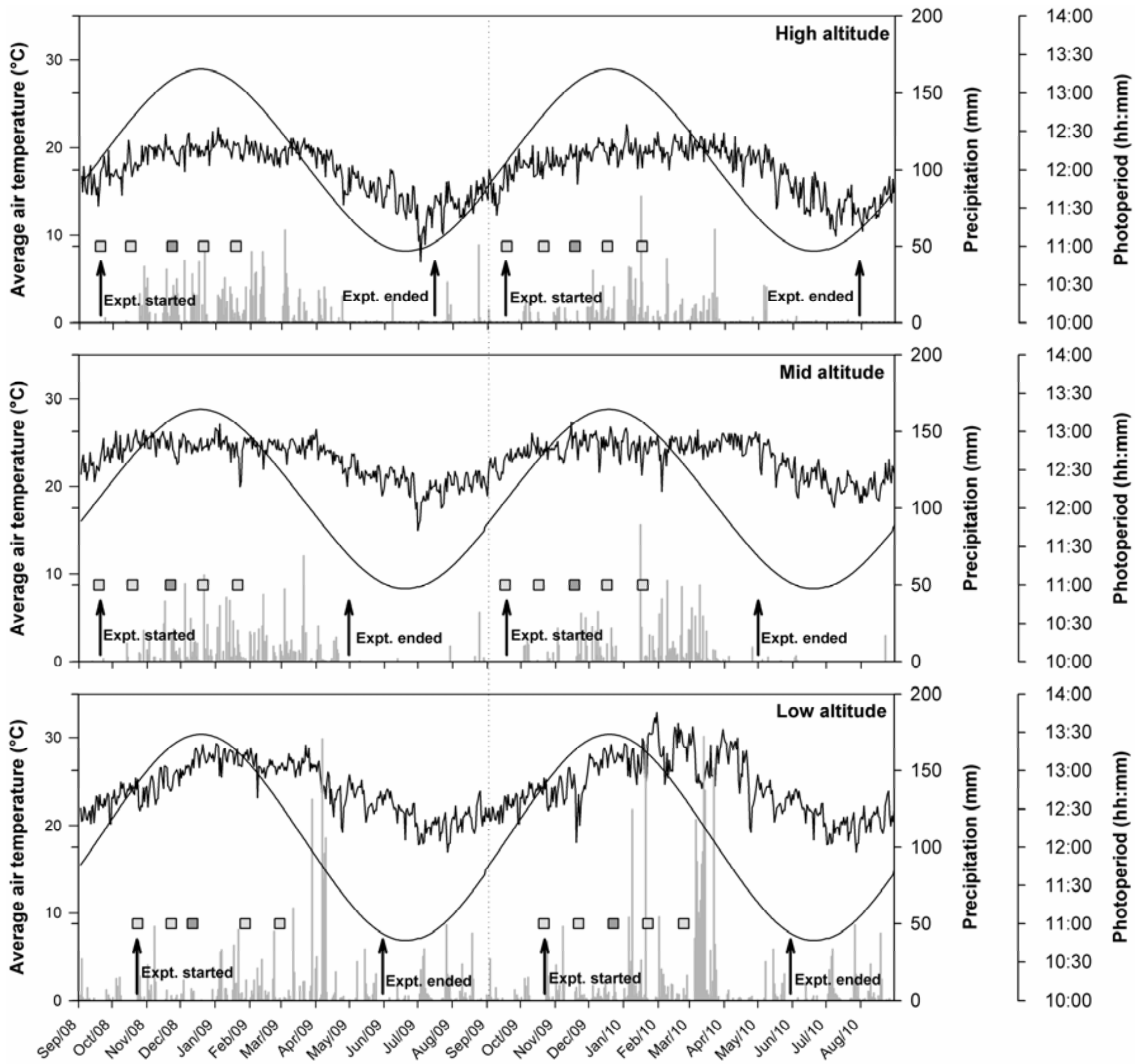
	Location		
	High altitude	**Mid altitude**	**Low altitude**
Latitude	19°46‘45.3“ S	19°33’16.8“ S	22°11’31.6“ S
Longitude	47°06‘24.5“ E	46°25’29.1“ E	47°52’32.7“ E
Elevation	1625 m asl	965 m asl	25 m asl
Altitude	High	Mid	Low
Precipitation	1300 mm	1200 mm	2100 mm
Tmin - Tmax	12.6 – 18.9 °C	19.4 – 23.8 °C	19.2 – 27.1 °C
Soil texture	Clay	Clay loam	Silt loam

Meteorology

Sowing	High altitude
1	Mid Sep
2	Mid Oct
3	**Mid Nov**
4	Mid Dec
5	Mid Jan

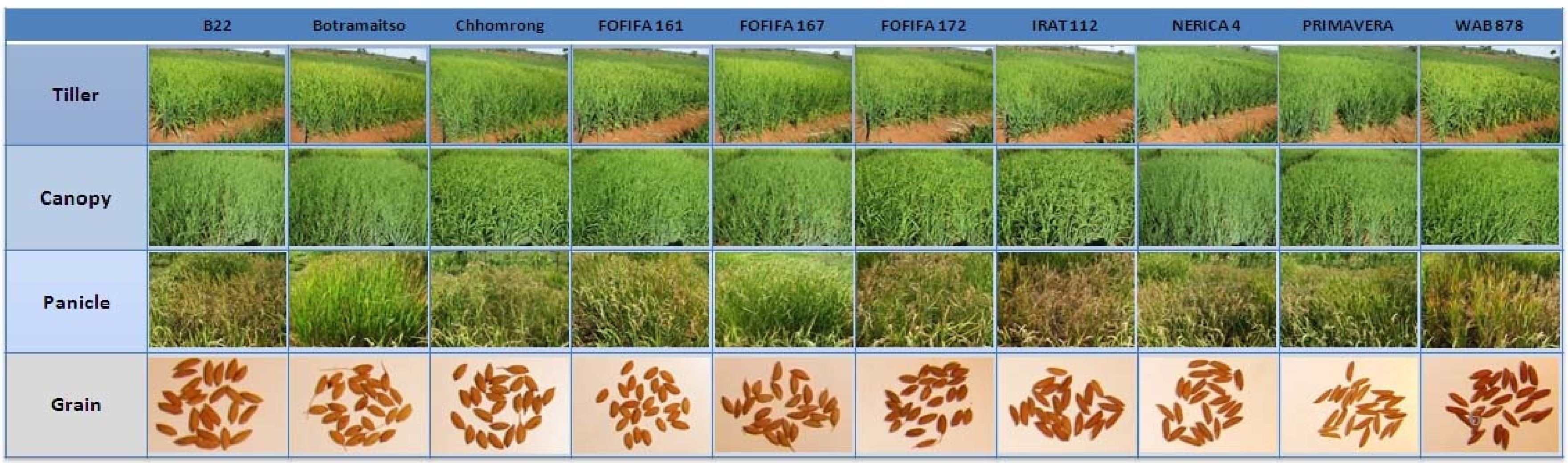
Sowing	Mid altitude
1	Mid Sep
2	Mid Oct
3	**Mid Nov**
4	Mid Dec
5	Mid Jan

Sowing	Low altitude
1	Mid Oct
2	Mid Nov
3	**Mid Dec**
4	Mid Jan
5	Mid Feb



Genotypes

Genotypes	Sub-species	Specific traits	Growing altitude
B 22	*O. Sativa* (tropical japonica)	Plasticity (aspect)	Mid-Low
Botramaintso	*O. Sativa* (tropical japonica)	Vigor growth	Mid
Chomrong	*O. Sativa* (temperate japonica)	Cold tolerant	High
FOFIFA 161	*O. Sativa* (tropical japonica)	Cold tolerant	High
FOFIFA 167	*O. Sativa* (tropical japonica)	Cold tolerant	High
FOFIFA 172	*O. Sativa* (tropical japonica)	Cold tolerant	High
IRAT 112	*O. Sativa* (tropical japonica)	Plasticity (aspect)	Mid
Nerica 4	*O. Glaberrima* x *O. Sativa* (interspecific crosses)	Stay green	Mid
Primavera	*O. Sativa* (tropical japonica)	Grain quality	Mid-Low
WAB 878	*O. Glaberrima* x *O. Sativa japonica* (interspecific crosses)	Vigor growth	Mid



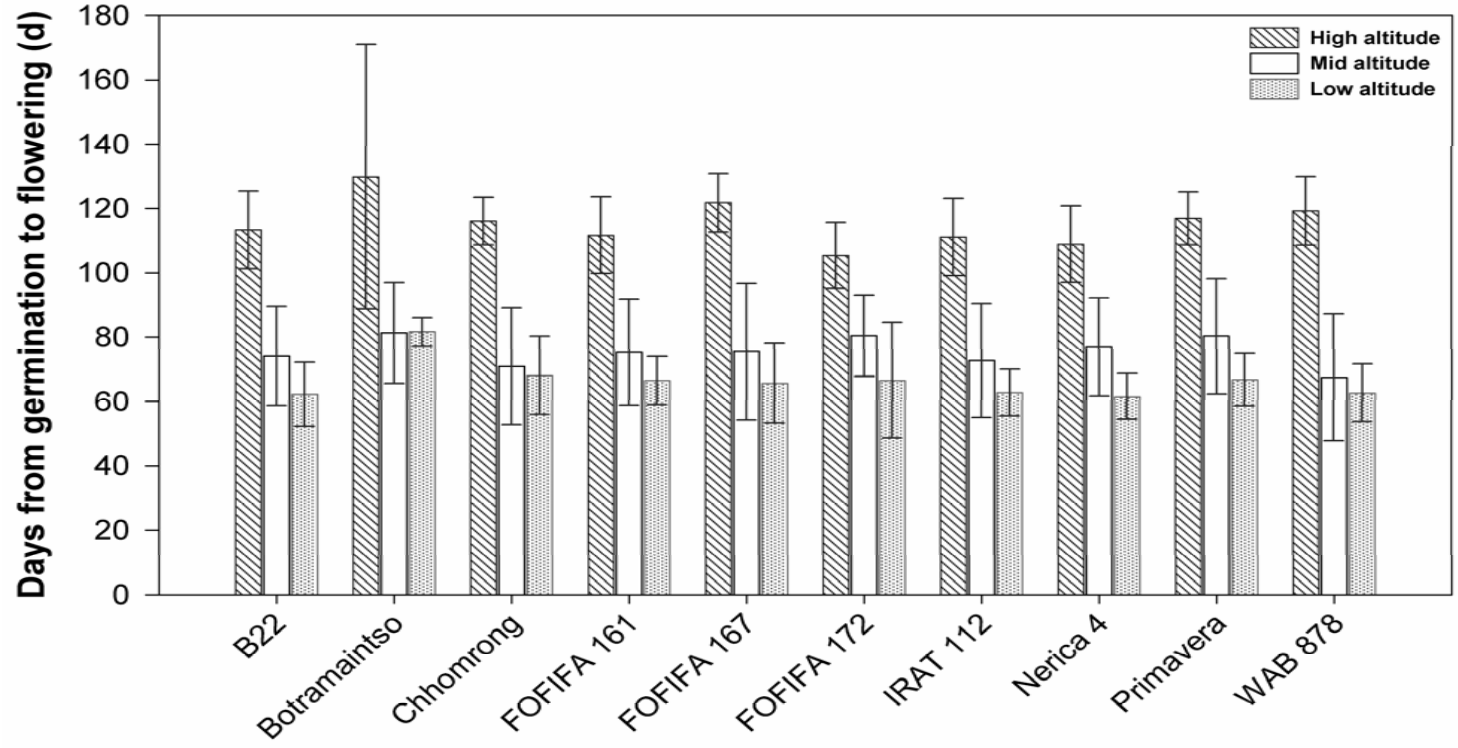
- 10 varieties of rainfed upland rice were planted at 5 monthly staggered sowing dates without replication in three locations for two years (phenological garden).
- Plot size was 1 X 1 m with 20 X 20 cm spacing between plants.
- Early sowing plots were manually irrigated to avoid drought stress.
- Phenological stages were carefully observed during the crop cycle.
- Biomass, yield, yield components and sterility percentage were determined at maturity.

Phenological Garden

(Mini Rice Garden)

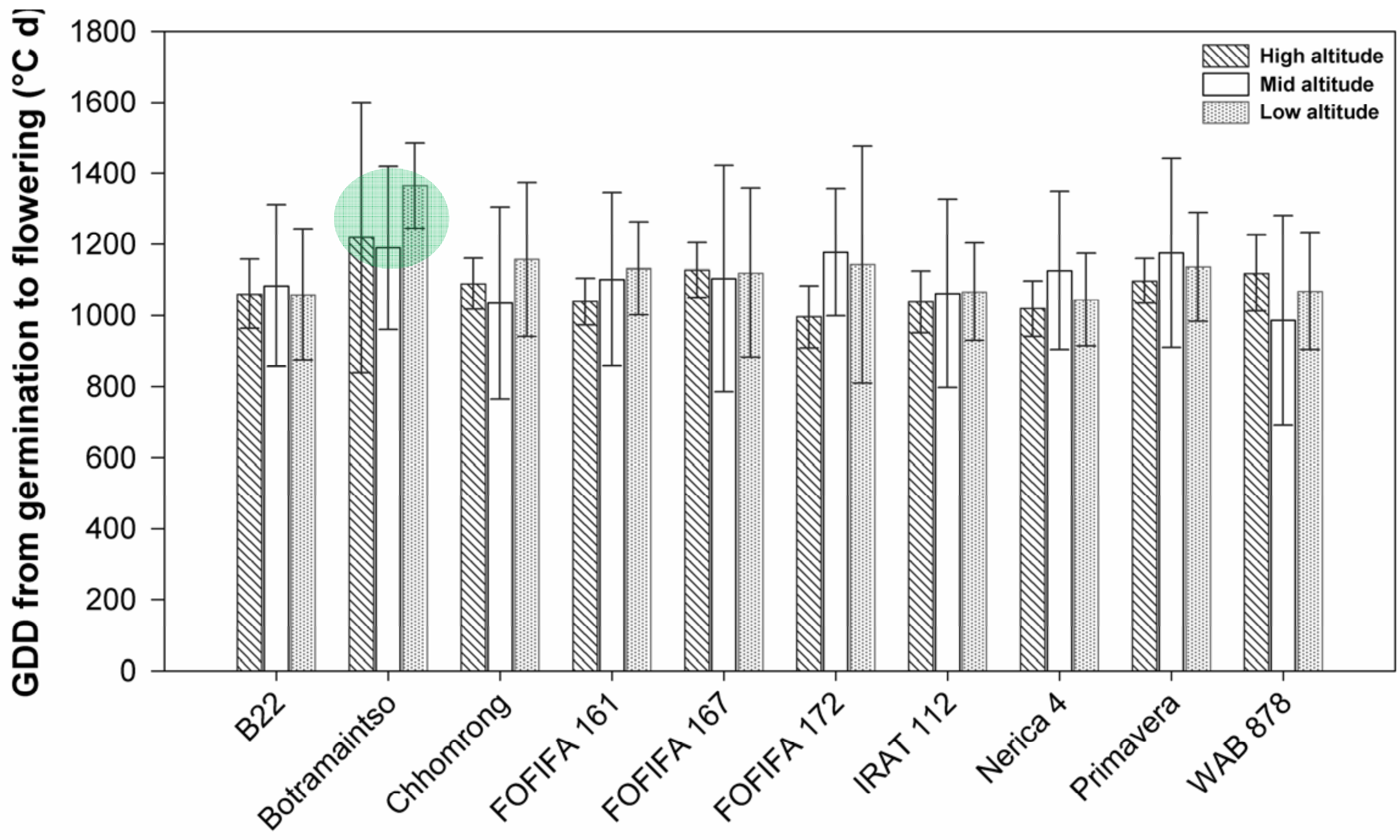
RESULTS and DISCUSSION

Calendar days



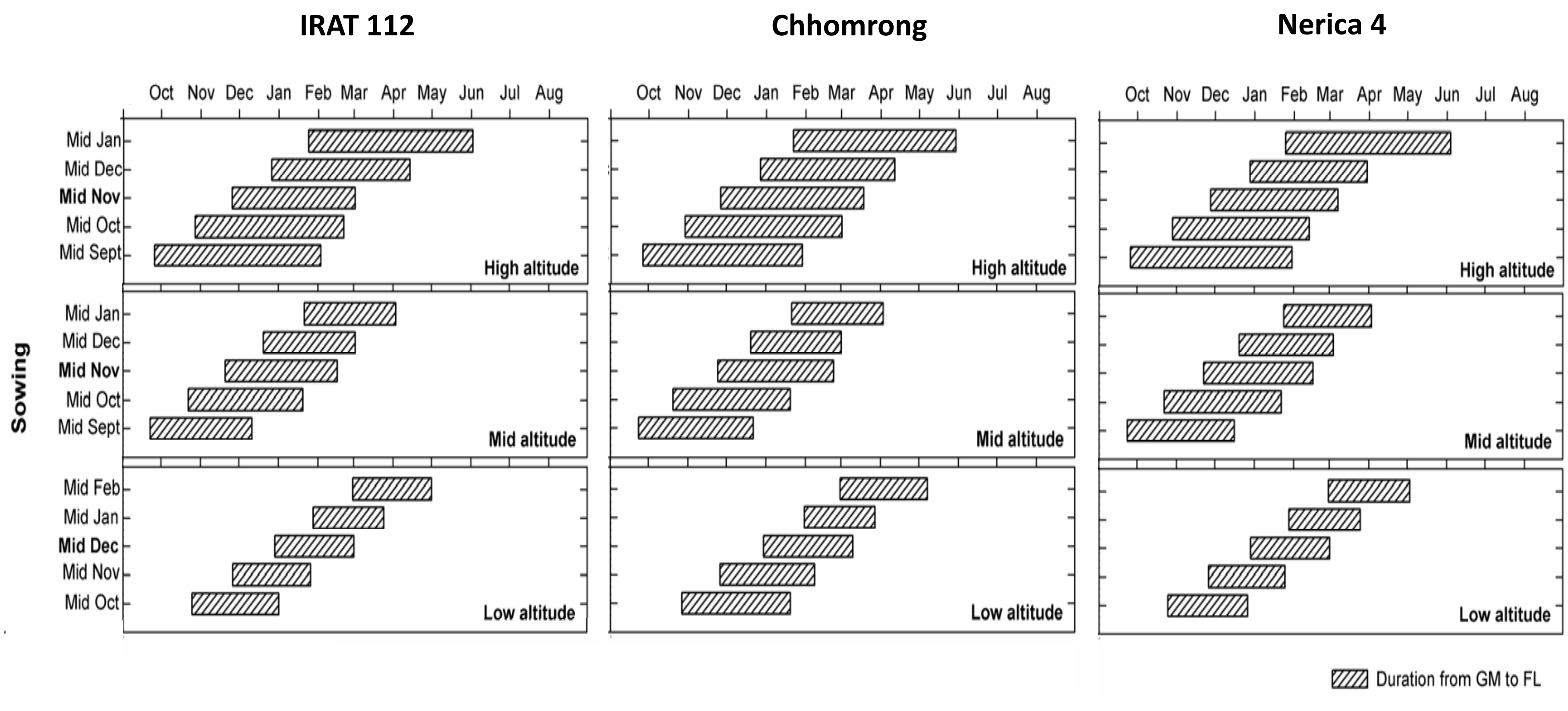
High altitude conditions increase crop duration by 36 to 52 days.

Thermal days (10°C base temperature used for all varieties)



The local landrace has higher thermal demand.

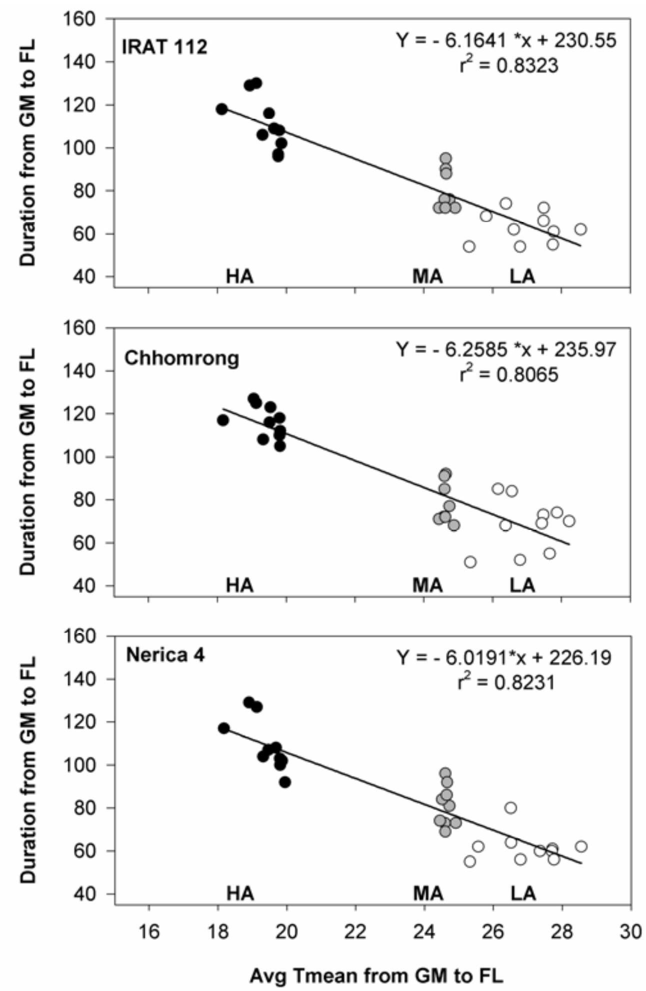
Sowing dates and crop duration (all varieties photoperiod insensitive)



Crop duration is only defined by temperature (via altitude).

Altitudes alter crop duration

Genotype	Slope	Intercept	r^2
B22	-6.5	239	0.800
Botramaintso	-8.9	314	0.851
Chhomrong	-6.3	236	0.807
FOFIFA 161	-5.9	225	0.823
FOFIFA 167	-6.9	254	0.778
FOFIFA 172	-4.8	199	0.554
IRAT 112	-6.2	231	0.832
Nerica 4	-6.0	226	0.823
Primavera	-6.5	244	0.851
WAB 878	-7.2	258	0.862



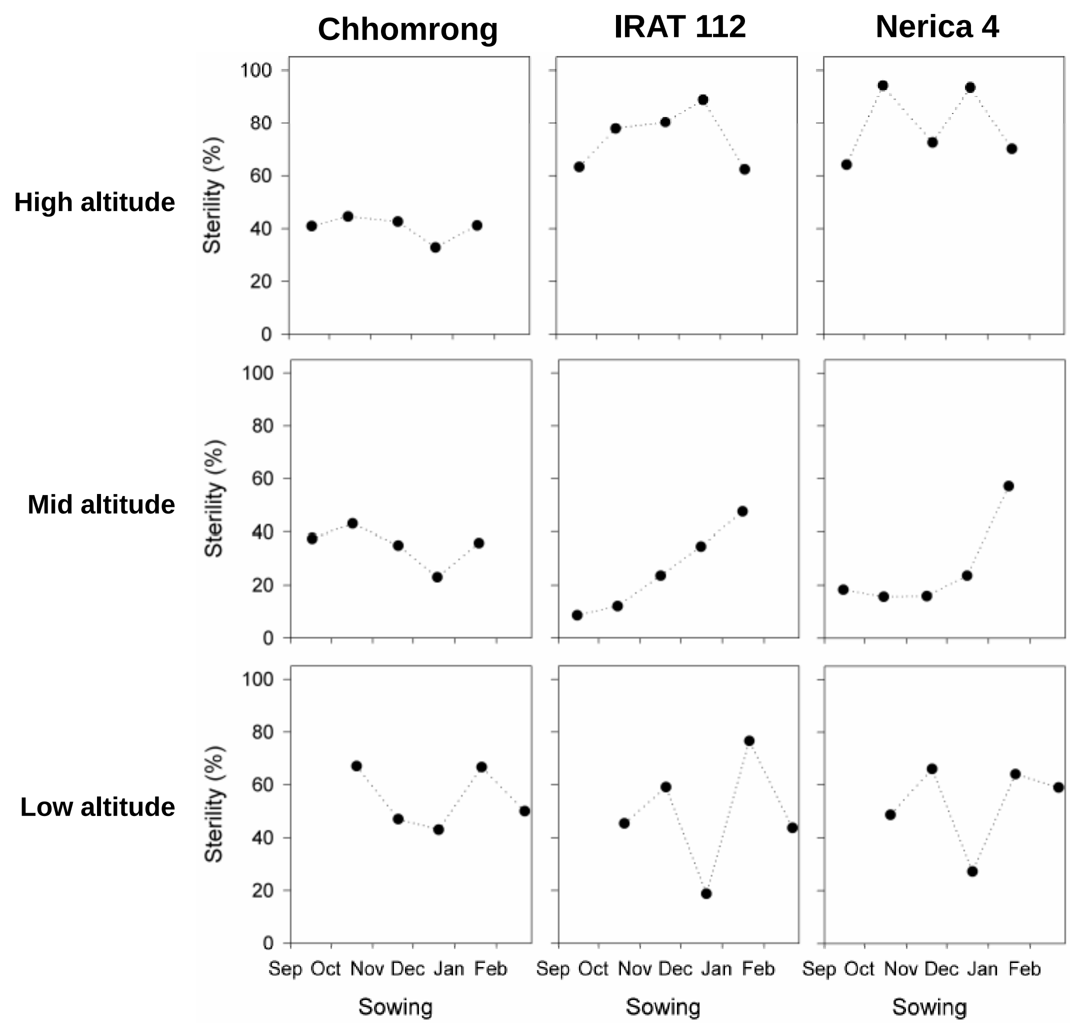
Rise in air temperature by 1°C decreases crop duration by 5 to 9 days from germination to flowering depending on genotype.

Spikelet sterility in different altitudes

Low temperature effects on sterility

Cold tolerant varieties perform well at high altitude

Genetic adaptation to cold environments can be exploited



CONCLUSION and OUTLOOK

- Predicted rise in air temperature is favourable for upland rice cultivation in the high altitude in terms of crop duration and grain yield.
- Genetic variation in cold tolerance can be used to adapt rice to cold environments.
- Morpho-physiological traits contributing to cold tolerance need to be identified for further breeding.

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THANK YOU